RAKE RECEIVER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a RAKE receiver which is used in a direct sequence spread spectrum communications system, and which can receive multipath signals effectively. The contents of Application No. 8-222,641, filed Aug. 23, 1996, in Japan is hereby incorporated by reference.

2. Description of the Related Art

A spread spectrum communication scheme is a communication method which multiplies a signal to be transmitted by a spreading code with a bandwidth of several to several ten thousand times the bandwidth of the signal at the transmitting side, and transmits it as a wideband signal, and which generates, at a receiving side, a despreading code in synchronism with the spreading code used for the spreading at the transmitting side, and recovers the narrow-band information by multiplying a received signal by the despreading code.

Recently, CDMA (Code Division Multiple Access) has been attracting attention which applies the spread spectrum communication scheme to multiple access of mobile radio systems. The spread spectrum communication method is characterized in resistance to noise and interference and in concealment of information.

In multipath propagation, it is possible to separate the multipaths at a resolution corresponding to the spreading code length in the process of despreading. Since the multipath signals arrive through different paths, their amplitudes and phases vary independently at the receiving point. In particular, fading occurs in mobile channels because the characteristics of a channels fluctuate with the movement of a mobile station. However, since the multipaths fluctuate independently, path diversity effect can be obtained by appropriately combining the multipath signals.

This scheme is called RAKE reception.

FIG. **1** shows a configuration of a conventional RAKE receiver. In FIG. **1**, the reference numeral **10** designates despreaders **(1)**–(n) each corresponding to one of the multipaths; **12** designates a path searcher for detecting timings of the multipaths, and provides the despreaders **10** with the timings; **16** designates detectors **(1)**–(n) for carrying out detection of the paths; and **18** designates a combiner for combining the outputs of the detectors.

Generally, the path searcher **12** is composed of sliding correlators capable of successively sliding the timing of the despreading, or matched filters matching the spreading codes, or the like.

The operation of the RAKE receiver shown in FIG. **1** will be described. First, the path searcher **12** measures the multipath state of a channel. Detecting the paths, the path searcher **12** sequentially operates the despreaders **10(1)–10**(n) at detected timings of the paths. In other words, the despreaders **10(1)–10**(n) each receive different multipaths. Since the multipath signals have undergone phase rotation and amplitude fluctuation, the detectors **16(1)–16**(n) compensate the phases and amplitudes.

Each pair of the despreaders **10(1)–10**(n) and detectors **16(1)–16**(n) is called a RAKE finger. The outputs of the RAKE fingers are combined by the combiner **18**. The combiner **18** can achieve more efficient reception than merely receiving a signal passing through a single path because the combined output is obtained which is the sum total of the signals passing through the multiple paths, thereby providing a received signal with reduced distortion due to fading.

Thus, the RAKE system can achieve multipath reception which improves the efficiency of incoming power reception, and which provides path diversity effect.

The RAKE receiver as described above in connection with FIG. **1**, however, will result in degradation in reception quality when it combines signals passing through the multipaths buried under noise as illustrated in FIG. **2**A.

FIG. **2**A illustrates the relationships between the noise level and the despread outputs of the received signals from the multipaths, and the inputs of the despread outputs to the respective detectors.

The RAKE reception often employs coherent detection as its detection method. This is because the coherent detection, when it operates ideally, requires a minimum signal-to-noise ratio (S/N ratio) for achieving a particular average bit error rate.

The coherent detection, however, sharply degrades its characteristics when applied to paths buried under the noise as illustrated in FIG. **2**A because of estimation errors of absolute phases.

In addition, efficient received power combining cannot be achieved when the number of multipaths exceeds the number of RAKE fingers as illustrated in FIG. **2**B. Increasing the number of the RAKE fingers, however, will result in combining the paths buried under the noise.

FIG. **2**B, like FIG. **2**A, illustrates the relationship between the noise level and the despread outputs of the received signals associated with the paths, and the despread outputs fed to the respective detectors. Here, the outputs not connected to the detectors represent that they do not have corresponding RAKE fingers.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a RAKE receiver which can achieve the RAKE combining making effective use of the received power even if there are paths buried under the noise, and which can implement high quality reception with reducing the distortion due to the noise.

In accordance with the present invention, a RAKE receiver comprises:

- a plurality of despreaders, each of which corresponds to a path among multipaths of a channel, and despreads a received signal of the path;
- a plurality of pre-detection combiners, each of which combines at least two signals delivered from the despreaders;
- a plurality of detectors for detecting outputs of the pre-detection combiners or outputs of the despreaders;
- a post-detection combiner for combining signals output from the detectors; and
- a path searcher for identifying the multipaths and for assigning the despreaders to the paths.

Here, the RAKE receiver may further comprise a switch for connecting outputs of the despreaders to desired ones of the pre-detection combiners, and for connecting the outputs of the despreaders to inputs of the detectors, wherein the path searcher controls a connection state of the switch.

The path searcher may dynamically change the connection state of the switch in response to an identification result of the multipaths.

At least one of the pre-detection combiners may combine a path with a signal level larger than a predetermined value with another path with a signal level smaller than the predetermined value.